# Upgrades and Partnerships Enhancing High-Dose Radiation Calibration at NIST

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National Institute of Standards and Technology
U.S. Department of Commerce

Medical Device Sterilization: Understanding the Possibilities

September 22, 2021 at 11:40 - 12:10 CDT

# Today's topics

Calibration services

Lab renovation and move

Acquisition of new irradiator

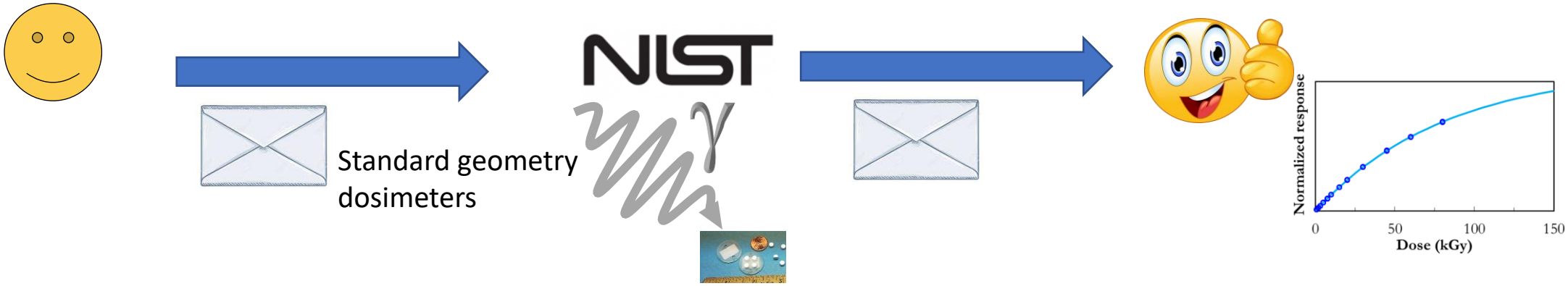
Consensus value to scale e-beam

ERDS collaboration

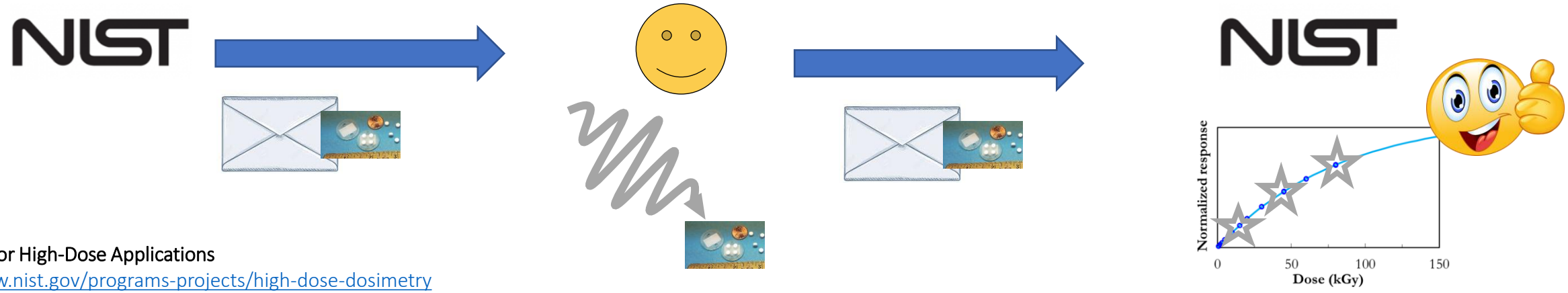
NOAC collaboration

# NIST High Dose calibration services

- Calibration Irradiations of Customer Supplied Dosimeters with Co-60 Gamma Rays (4901XC)

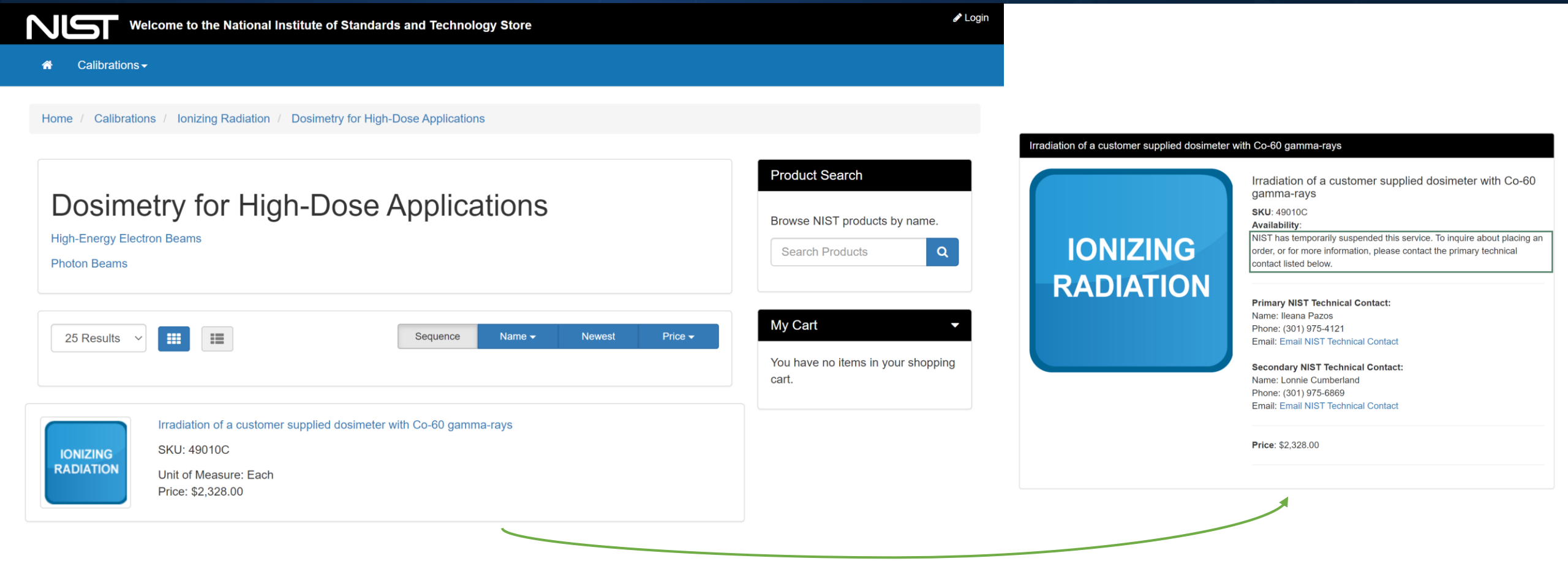



- Dose Interpretation of Customer-Irradiated NIST Transfer Dosimeters (4902XC and 4903XC)




Dosimetry for High-Dose Applications
https://www.nist.gov/programs-projects/high-dose-dosimetry
Quality System for Calibration Irradiation and Transfer Dosimeters
https://www.nist.gov/pml/radiation-physics/ird-quality-system-procedures

# NIST storefront



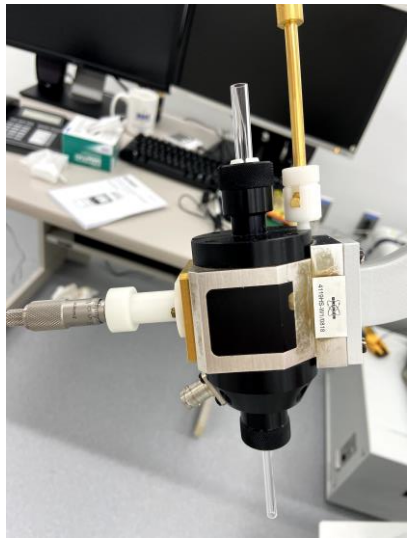

On March 27, 2019, NIST introduced a new online shopping experience to order Calibration services.

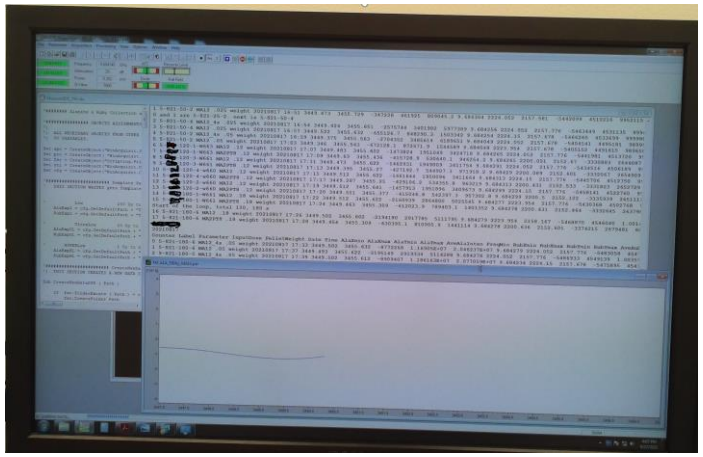
Click here to access the new NIST storefront

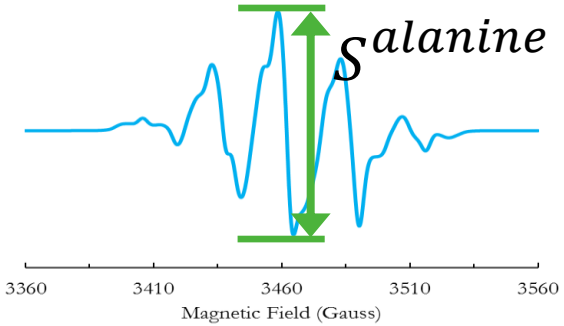
# Renovated EPR facility

- 4 EPR spectrometers and support instruments moved to renovated space.
- Services are suspended during the move, setup and testing.
- Revalidation of the service is in progress.

# EMX enhancements





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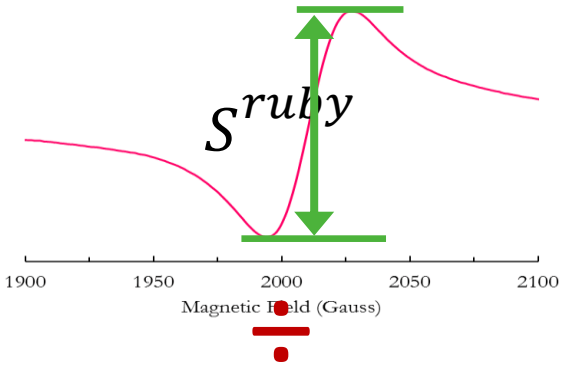


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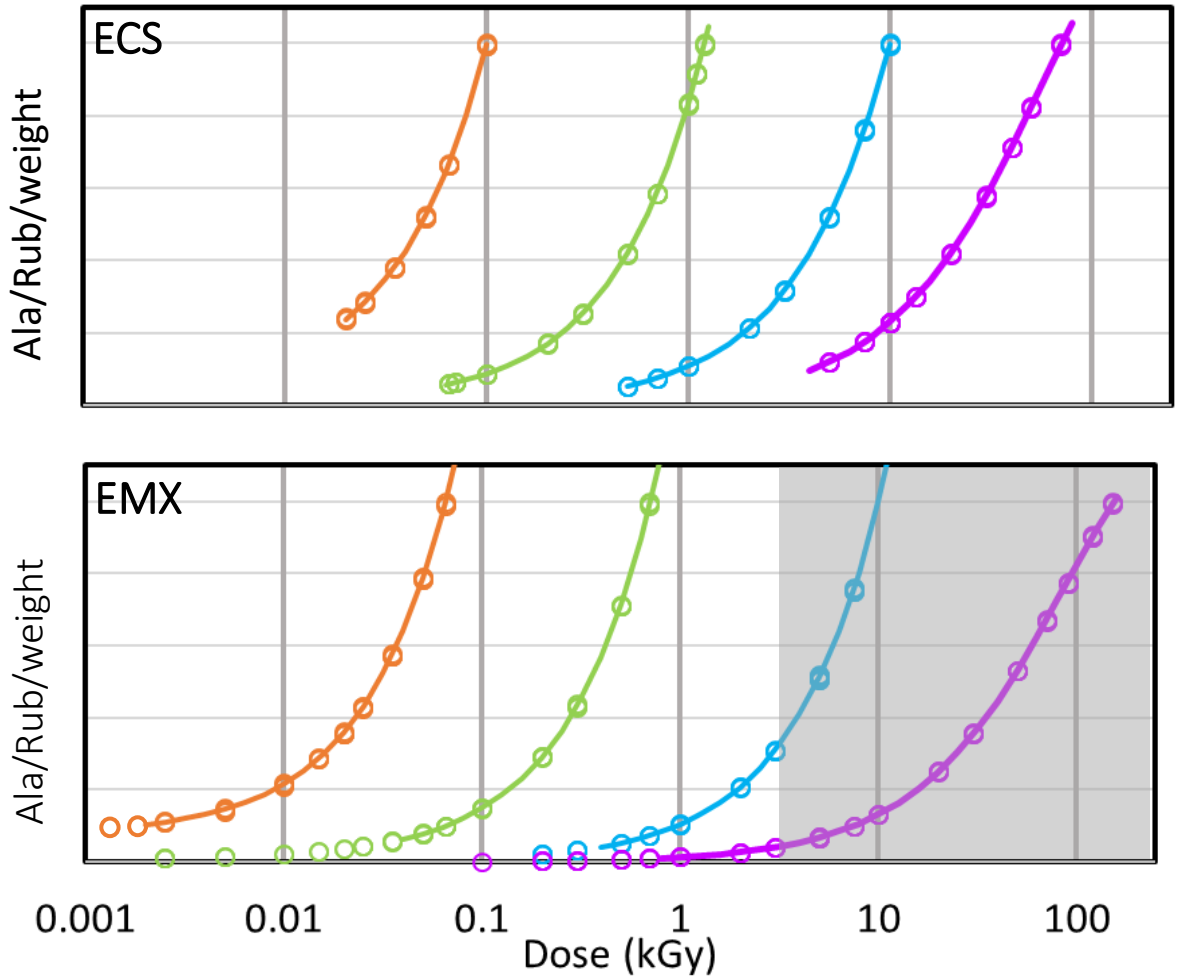
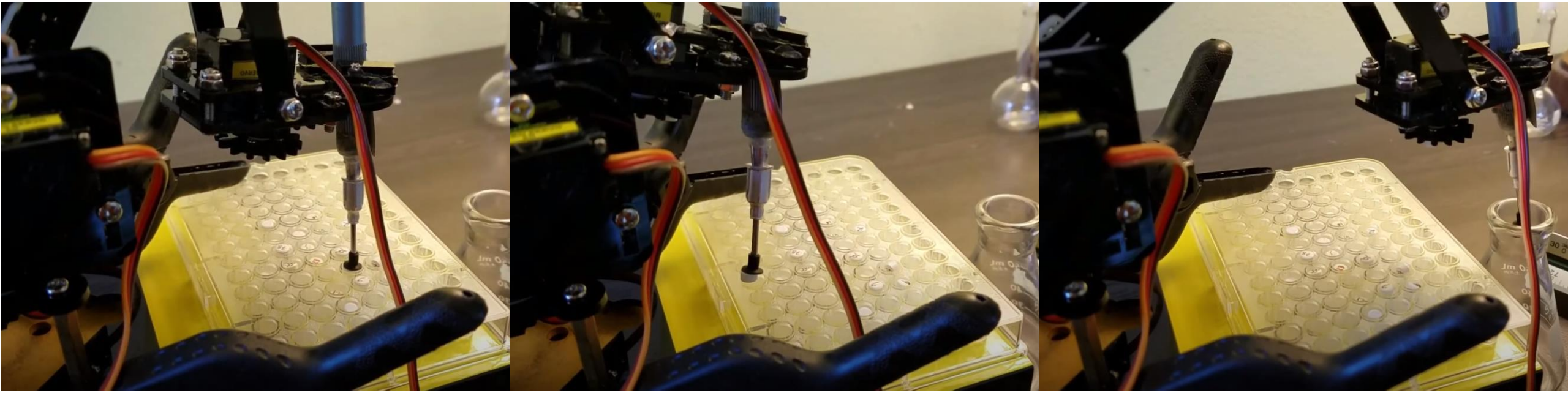
EPR calibration curves



# Automatic pellet exchange system



Virtual summer student project: vacuum pen, pellet tray, pellets, and a robot arm were sent to the student's home.

Next steps: setup near EMX and integrate in auto-collection.

# Dose Rate Effect

Limiting upper dose for alanine dosimeters

Rate effect is estimated to be

- zero at dose rates above 2 Gy/s
- significant at some value below 2 Gy/s, and
- clearly measurable at 1 Gy/s

Rate effect depends on absorbed dose, it

- is not measurable at 1 kGy or less
- becomes significant above 5 kGy
- reaches a maximum effect at about 30 kGy

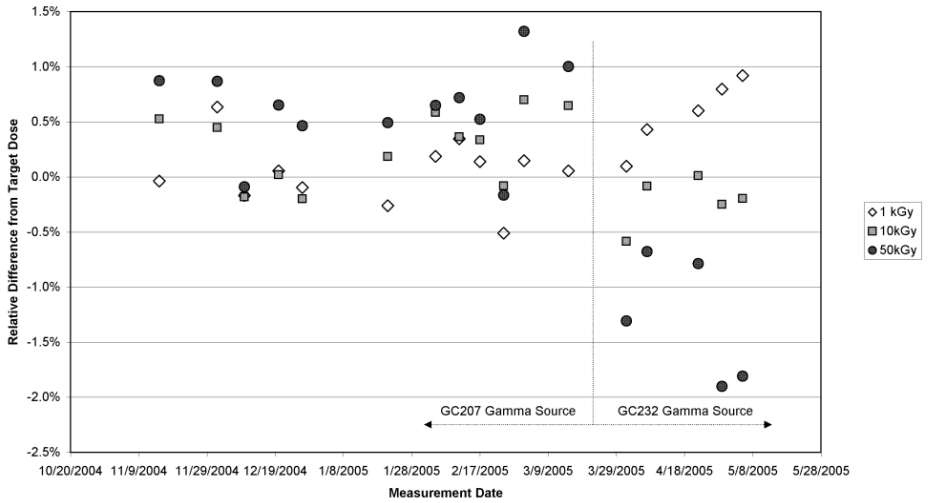
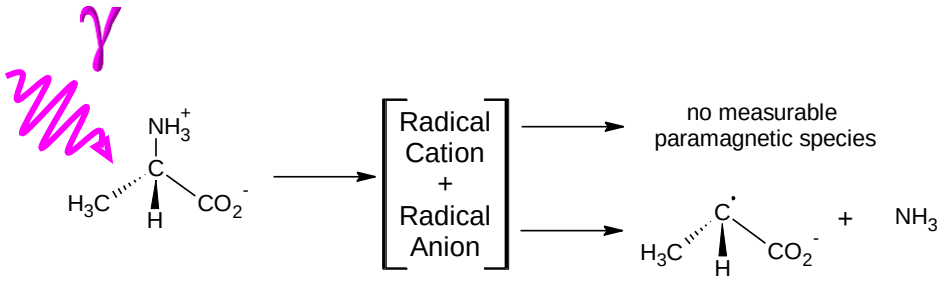



**Fig. 1.** A quality-control check-standard plot for the high-dose transfer dosimetry service. The relative difference of the computed absorbed dose for the check-standard measurement from the absorbed dose delivered is plotted versus the measurement date. Three doses were measured on each date: 1 kGy, 10 kGy, and 50 kGy (the symbols for each are defined in the legend). Dosimeters that measured ± 1 % from the target dose are deemed acceptable.

The effect is intrinsic to alanine and is not dependent on the chemical form or manufacturing formulation of the alanine dosimeter.

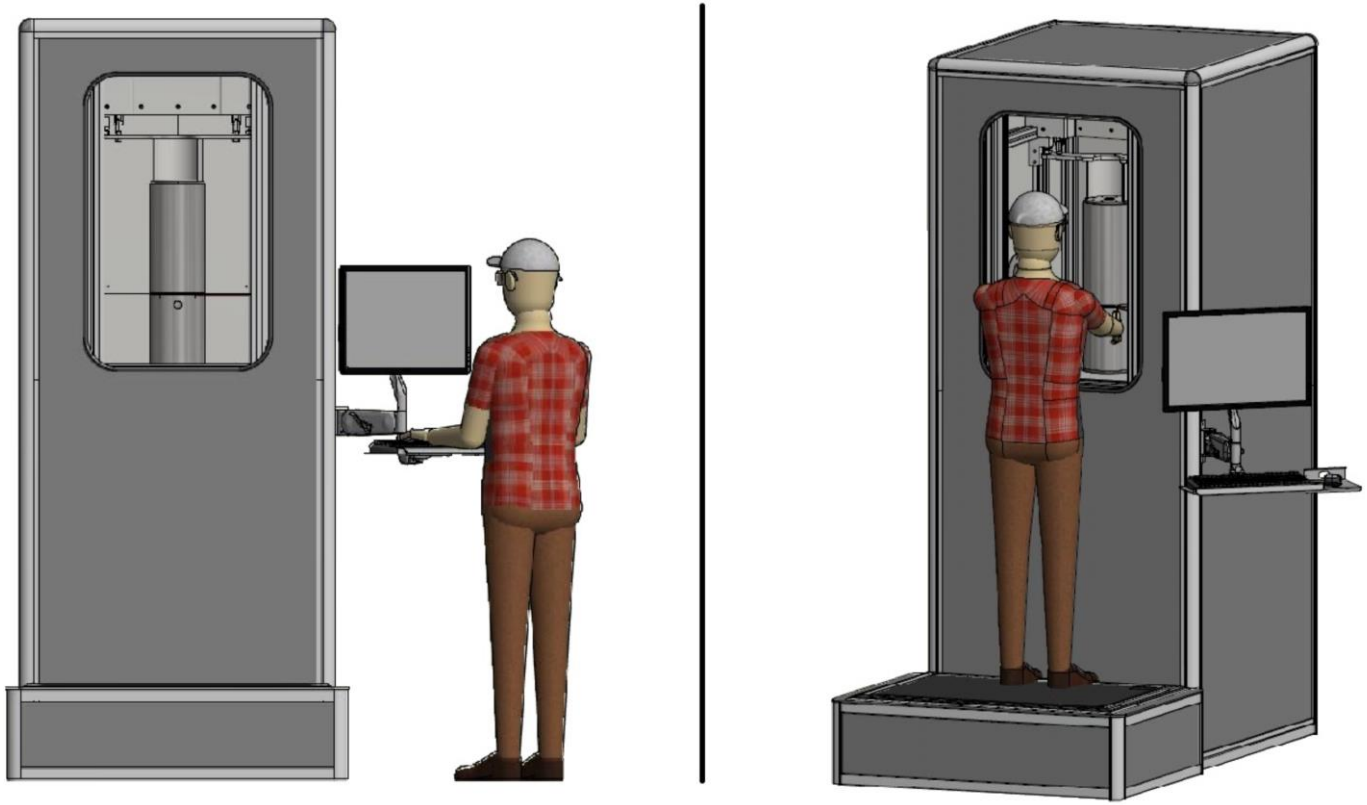
The study postulated that the production of one (or more) of the radiation-induced alanine radicals is dependent on the dose rate.




Desrosiers et al., 2008 and Desrosiers and Puhl, 2009

https://www.nist.gov/programs-projects/basic-metrology-dosedose-rate-effects-alanine-dosimetry

# Acquisition of new irradiator



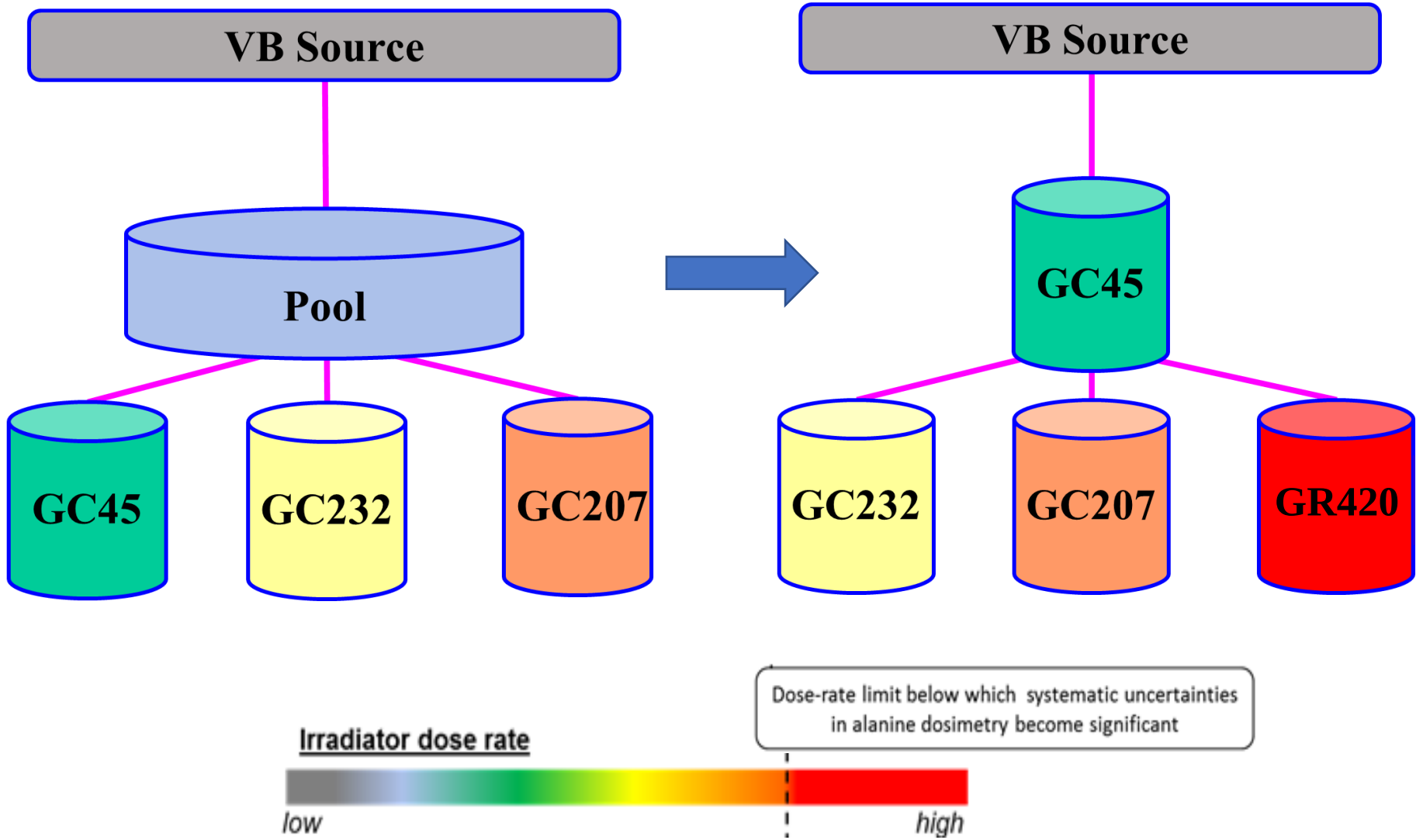
The Hopewell Designs, Inc. Model GR420 High Dose Rate Self-Contained Research Irradiator is a modern replacement for the legacy systems which are no longer supported.

The GR420 combines the well-known and understood capabilities and features of legacy systems with numerous state-of-the art design upgrades including larger chamber volume, a rotating chamber, higher precision timing/process control and greatly improved external (operator) dose rates.

https://www.hopewelldesigns.com/products/self-contained-irradiators/

# NIST traceability

- NIST high-dose calibrations and irradiation services are performed in GammaCell Co-60 irradiators (designated **GC**).
- Metrology is based on alanine-EPR dosimetry, traceable to the primary standard water calorimeter under the Co-60 vertical beam (**VB**).

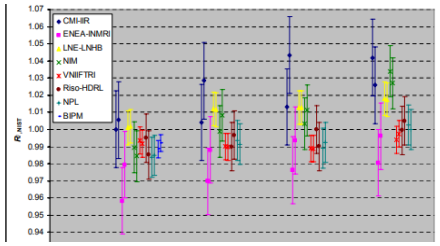


# Comparisons

## CCRI-S3

The Consultative Committee for Ionizing Radiation (CCRI) third supplementary comparison (S3) of standards for absorbed dose to water in Co-60 gamma radiation was completed

**7 laboratories participated**




## New NIST irradiator

Dose rate determined by comparison to NIST irradiators (< 5 kGy)

International comparison for higher dose will be completed

**validate GR420**

## ASTM Proficiency Test

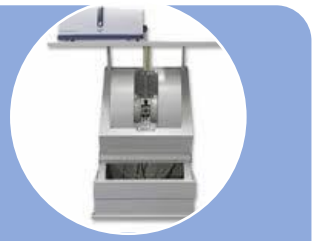
Proficiency Test Plan for the Characterization and Evaluation of High-Dose Dosimetry Techniques in Radiation Processing

**industry comparison**

# Revalidation plan

| | | | | | |
|---|---|---|---|---|---|
| **Phase I:** March –TBD | Suspend HD T&G (all doses) | **Move EPR lab to renovated space; Set up spectrometers** | Update Hazard Reviews/SOPs | Re-establish calibration curves < 5 kGy Using legacy irradiators | Revalidate restart T&G < 5 kGy |
| **Phase II:** TBD | **Irradiator lab # 2 renovation complete and receive GR420** | Update Hazard Reviews/SOPs | Initial safety and uniformity testing | Establish dose rate & traceability. Determine geometry & temperature correction factors; Comparisons | Validate and start T&G < 100 kGy |
| **Phase III:** TBD | **Irradiator lab # 1 renovation begins** | Partial operation ✓ T full range ✓ G > 1 kGy * ✗ G < 1 kGy * | Update Hazard Reviews/SOPs | | |
| **Phase IV:** TBD | **Renovation of irradiator lab # 1 is completed** | Fully operational | | | |

**HD -** high dose
**T** - transfer calibration service
**G** - irradiation calibration service
* - lower dose range TBD



EPR Lab

Irradiator Lab #1

Irradiator Lab #2

# Scaling factor for high energy electron beam

Review of literature from the last 15 years on scaling from Co-60 to electron beams.

Recommendation by the lead laboratories providing alanine calibration services.

An overall conversion factor of 1.014 (standard uncertainty = 0.5 %) was obtained.

Alanine dose readings determined from a Co-60 alanine calibration should be multiplied by this factor to yield the dose delivered in an electron beam.

ELSEVIER

Radiation Physics and Chemistry

Volume 171, June 2020, 108673

## Determination of a consensus scaling factor to convert a Co-60-based alanine dose reading to yield the dose delivered in a high energy electron beam

Malcolm McEwen [a], Arne Miller [b], Ileana Pazos [c], Peter Sharpe [d]

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https://doi.org/10.1016/j.radphyschem.2019.108673

# 2021 CIRMS meeting

## Industrial Applications Subcommittee

(chair: Ileana Pazos, PhD, National Institute of Standards and Technology)

*Current Solutions and Needs in Dosimetry for Radiation Processing Applications*
Mike Pageau, GEX Corporation

*Chip-Scale, Integrated Photonics for Radiation Dosimetry and Calorimetry*
Nikolai Klimov, PhD, National Institute of Standards and Technology (NIST) Gaithersburg, MD

*Recent Advances Towards a Deployable Emergency Response Dosimetry System (ERDS)*
Jason Campbell, PhD, National Institute of Standards and Technology (NIST) Gaithersburg, MD

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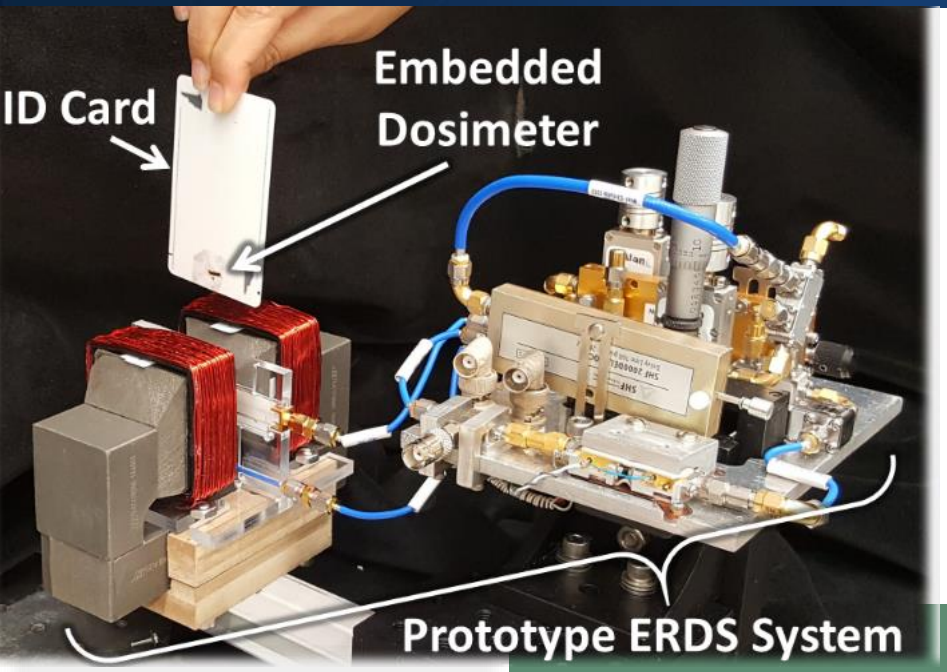
# Emergency Radiation Dosimetry System

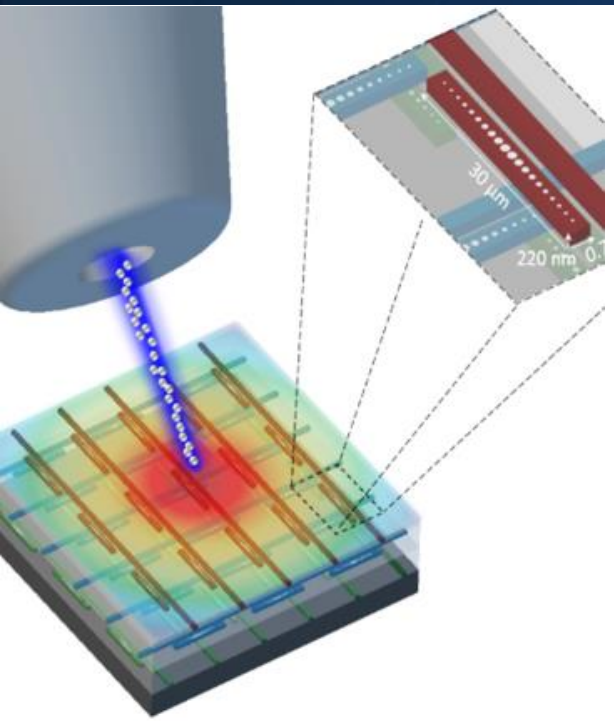



- NIST and Global Resonance Technologies LLC are developing a robust, sensitive and portable device to rapidly measure the amount of radiation received by exposed individuals in the aftermath of a mass-exposure nuclear event.
- Small embedded dosimeters in ID cards are a cost-effective way of distributing large numbers of dosimeters as a pre-event mitigation strategy.


- Smaller alanine dosimeters coupled with an EPR system that can detect 1 – 5 Gy could be adapted to industrial needs.
- Plastic encapsulation could be coded and tracked.
- The new dosimetry system has been demonstrated to be suitable for electron beam irradiations.

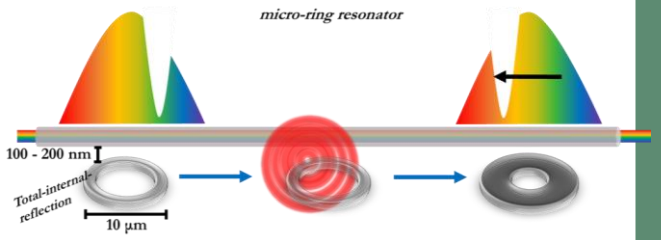
https://www.nist.gov/noac/technology/radiation/emergency-dosimetry

# NIST on a Chip




- By measuring the temperature rise in silicon devices due to radiation absorption, NIST researchers have taken the first step toward a miniaturized version of the conventional calorimetry technique.
- The chip-based device detects how heat energy affects the properties of light passing through microscopic channels being irradiated by gamma rays or an electron beam.

https://www.nist.gov/noac/technology/radiation/photonic-sensors




- By leveraging nanomanufacturing and telecommunications technology, the new sensor promises highly accurate readings at smaller dimensions.
- Exploring different doping strategies that would result in accumulated defects would convert this calorimeter into a dosimeter.

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# STAY IN TOUCH

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